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A STUDY OF THE POWER USED ON 62 PENNSYLVANIA FARMS, 1938

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Washington, D. C.
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CONTENTS

	Page
Introduction	1
Description of the farms and areas	4
Use of tractors	7
Number and kinds of tractors used	7
Extent of tractor operations	7
Rates of performing field operations with tractors	11
Cost of operating tractors	12
Annual hours of use and length of life of tractors	13
The use of horses	15
Extent of horse operations	15
Horses required	15
The use of farm motortrucks	15
Number and kinds of motortrucks used	15
Extent of motortruck operations	18
Cost of operating motortrucks	18
Adjustments made by farmers in the organization of their farms following the substitution of tractor power for horse power	19

INTRODUCTION

Agriculture is undergoing extensive change in an effort to incorporate effectively within its framework recent technological developments applicable to it. This is especially true in this country.

Maladjustments often initiated by the widespread adoption of new techniques may not be removed easily, either by an automatic functioning of the economy as a whole or by programs and policies established by public agencies for the express purpose of correcting them. Under such circumstances a greater than usual number of persons come to regard technology with skepticism; they doubt that technology contributes to the well-being of the general population. They brand it a "demon" and make it the scapegoat for a great many, if not all, of our economic and social ills. Not all people accept this point of view, however, and some who do not, look upon technology with great optimism. They minimize the maladjustments that may follow the general adoption of new techniques and hold to the opinion that technology always contributes to the general welfare. It is sufficient to say here that neither of these extreme concepts of

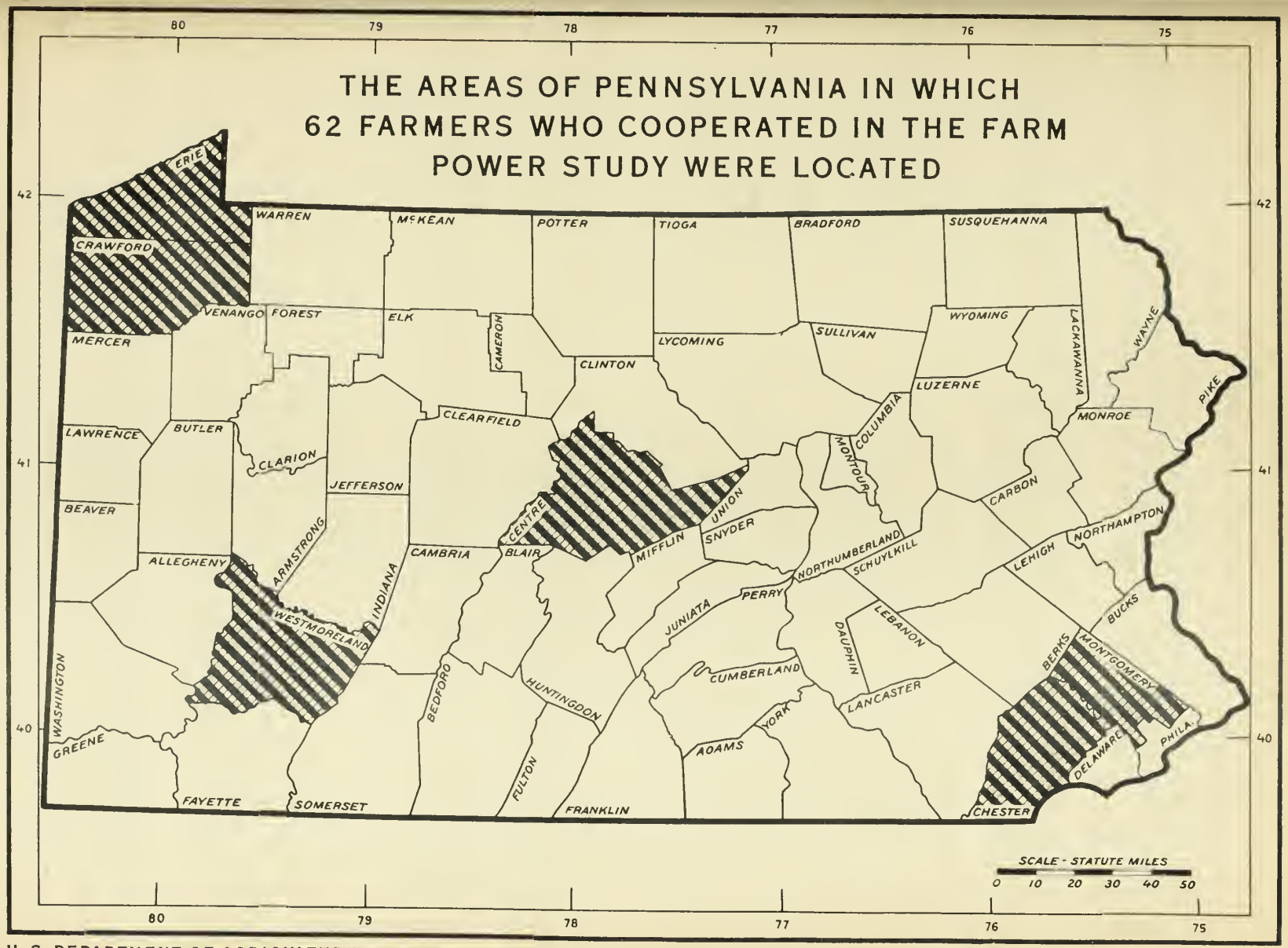
technology is complete in itself. A more realistic point of view embraces parts of each, but not one to the exclusion of the other.

Of the recent technological developments affecting agriculture, those in the field of farm power and equipment carry with them social and economic consequences rivaled by few, if any, of the effects of other developments. To be sure, these consequences are not of the same importance in each of the geographic divisions of the United States. In the North Atlantic Division, of which Pennsylvania is a part, they are of less importance than in certain other areas, but are still worthy of consideration by those interested in the problems of agriculture. With respect to the State of Pennsylvania alone, the fact that the number of tractors on farms increased from 33,513 in 1930 to 54,786 in 1939 1/ indicates that the implications deserve more than minor consideration. Because there were few data available concerning the detailed use of power on Pennsylvania farms, a farm-power study was outlined for Pennsylvania farms during the summer of 1939.

The principal objectives of the study were to observe the organization of farms that were using tractors as a source of power; to ascertain the types and sizes of tractors used on farms; to find the extent to which tractors, horses, and other sources of power were used on farms during the course of the year; and to study adjustments that farmers make in their farm organizations following an alteration of the type of power.

Data covering the farming operations for the calendar year 1938 were obtained for individual farms by survey methods during the months of June and July. Sixty-two farmers located in four areas of the State cooperated. Ten of the farms were located in Chester and Montgomery counties (the Southeastern Area), 19 in Centre County (the Central Area), 17 in Westmoreland County (the Southwestern Area), and 16 in Crawford and Erie counties (the Northwestern Area). (See map, page 3.) The area designations do not refer to type-of-farming areas within the State; they are used merely for the purpose of facilitating reference to the counties that were included in the study.

1/ The 1930 figure is taken from the 1930 U. S. Census, the 1939 from Farm Implement News, April 6, 1939.



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DESCRIPTION OF THE FARMS AND AREAS

Southeastern Area

The farms of the cooperating farmers possessed a somewhat broken topography. Of the cropland - land occupied by field crops, fallowed, or idle but not abandoned - 6 percent was level, whereas 49 percent was gently rolling and 45 percent rolling.

Soils of the cropland belonged primarily to the Chester, Penn, and Lansdale series. Clays and clay loams predominated - 60 percent of the cropland soils being of these kinds - while silt loams and sandy loams each made up 20 percent.

The 10 farms in the Southeastern area averaged 209 acres in size, ranging from 106 to 409 acres. Cropland made up 69 percent of the total farm acreage, 2 percent represented rotation pasture, 4 percent permanent plowable pasture, while the rest - 25 percent - was non-tillable and miscellaneous land, that is, land used for permanent non-plowable pasture, woodlots, roads, and farmsteads. The surveyed farms were much larger than the average farm in the area. The average farm comprised 48 acres in Montgomery County and 79 acres in Chester County in 1935. In each county in 1930, more farms were between 50 and 99 acres in size than between any other size limits employed by the census. Further evidence that the surveyed farms were larger than most farms in the area was the fact that large quantities of hired labor were used on them. Available data indicate that 6 of the 10 tractor farms used an equivalent of 39 months of hired labor during the year in addition to the labor of the operator.

The type of farming prevailing in the area has been described as dairy and poultry 2/. The data collected suggest that the cooperating farms are representative of the farms in these counties. A picture of crop and livestock systems on the surveyed farms in the four areas is given in table 1.

The number of tractors reported on farms of the area in 1939 was 4,142. When compared with the number of farms reported for the area in 1935 it is observed that there was one tractor for approximately every two farms.

Central Area

Farms included in the study were located in the Nittany, Penn, and Brush Valleys, or their extensions, and in the Bald Eagle Valley that marks the boundary between the Allegheny Mountains and Plateau Province and the Appalachian Ridge and Valley Section. Approximately 25 percent of the cropland was level, 42 percent was gently rolling, 32 percent rolling, and 1 percent sharply rolling.

The cropland soils were to a large degree Hagerstown clay and clay loams. These soils comprised 61 percent of the total, while 14 percent was silt loams, 3 percent sandy loams, and 22 percent gravelly.

2/ Rauchenstein, Emil, and Weaver, F. P. Types of Farming in Pennsylvania. Pa. Agr. Expt. Sta. Bul. 305, 63 pp. State College, 1934.

Table 1. - Average acreage of different crops and numbers of livestock per tractor farm in each of four areas of Pennsylvania, 1938

Kind of Crop or Livestock	Area			
	South-eastern	Central	South-western	North-western
	Acres	Acres	Acres	Acres
Crops				
Corn - For grain	27	17	12	9
For silage	10	7	4	11
Small grain Wheat	29	21	16	7
Oats	8	21	17	17
Barley	6	1	2	1
Rye	-	1/	-	-
Buckwheat	-	1/	-	8
Soybeans for grain	-	-	-	1
Hay - Annual -				
Soybean	2	1	1	1
Oats	-	1	-	-
Other -				
Alfalfa	8	8	12	1/
Red clover	2	2	1	14
Timothy & clover	9	18	12	9
Meadow	10	1	2	1
Miscellaneous	3	2	11	2
Orchard	9	1	2	1
Cover crops	1	1/	2	1
Truck crops - Irish potatoes	9	1	-	1
Cabbage	-	-	-	4
Miscellaneous	4	1/	1/	1/
Total acres of crops	137	102	94	88
	Number	Number	Number	Number
Livestock				
Milk cows	21	13	16	21
Other cattle	18	10	13	13
Sows and gilts	3	3	2	1
Breeding sheep	2	5	-	1
Poultry - Laying flock 2/	580	76	219	123
Other poultry 3/	1,805	130	329	102
Workstock Mature	2	2.5	1.5	3
Colts 1-year and over	-	0.3	0.1	0.1
Colts under 1-year	-	0.3	-	0.1

1/ Less than 0.5 acres.

2/ Numbers as of Dec. 31, 1938 except for "other poultry".

3/ Includes all types of poultry, exclusive of the mature laying flock, that were raised on the farm.

Average size of the 19 farms was 273 acres. Forty-three percent of the total farm acreage was cropland, 1 percent was rotation pasture, 7 percent permanent plowable pasture, while 49 percent was non-tillable and miscellaneous. The total farm acreage was distributed among the different land uses in the manner indicated because 2 of the 19 farms had extensive holdings of timberland - one embracing 679 acres and the other 747 acres. With these 2 farms excluded, the average size of the remaining 17 farms would be 191 acres and the distribution of this acreage among the four land use classes would be 56 percent to cropland, 1 percent to rotation pasture, 9 percent to permanent plowable pasture, and 34 percent to non-tillable and miscellaneous. Not one of the 19 farms was so small in size as the average farm in Centre County in 1935.

The average size of all farms in the county in 1935 was 116 acres. Farms of 100 to 174 acres were more numerous in 1930 than were farms of any other size group. Of the 19 farms studied, 12 fell within these size limits. The 1938 labor requirements of the tractor farms, however, further suggested that they were above average in size. Eleven of the 19 farmers reported that an average of $14\frac{1}{2}$ months of hired labor were used on the farm during the year.

The area is characterized by dairy and general farming.

In 1939 a total of 847 tractors were on farms within the area. This was equivalent to about 1 tractor for every $2\frac{1}{2}$ farms.

Southwestern Area

The 17 farms of this area were perhaps more rugged in topography than were these of any of the other areas studied. Seven percent of the cropland was level, while 58 percent was gently rolling, 30 percent rolling, and 5 percent sharply rolling.

Cropland soils were classified as 49 percent clays and clay loams, 22 percent silt loams, 28 percent sandy loams, and 1 percent gravelly.

Farms were of a smaller total acreage than those of the other three regions - average size being 146 acres - but each farm had a slightly greater acreage of cropland than those in the Northwestern area. Of the total farm acreage 66 percent was cropland, while 13 percent was permanent plowable pasture, and 21 percent non-tillable and miscellaneous. The farms, nevertheless, were larger in size than those in Westmoreland County as a whole. Average size of all farms in the county in 1935 was 78 acres — 10 acres under the smallest of the 17 farms. Distribution of all farms of the county in 1930 revealed that a greater number fell within the size group of 50 to 99 acres than any other of the size groups used. The labor requirements of the tractor farms indicate further that the farms were above average in size. Twelve of the farmers indicated that they used an average of about 16 months of hired monthly labor, some hired day labor, and their own labor during 1938.

Dairy and general farming are the important types of farming found in the area.

The concentration of tractors was less than in either the Southeastern or Central Area, being 1 tractor for every $3\frac{1}{2}$ farms.

Northwestern Area

Comparatively level cropland prevailed on the 16 farms in this area. As much as 74 percent of the cropland was classified as level, while only 18 percent was considered gently rolling and 8 percent rolling.

Cropland soils of the area were coarser than those found in the other areas. They belonged to the Volusia series and were designated as 29 percent clays and clay loams, 11 percent silt loams, 7 percent sandy loams, and 53 percent gravelly.

The average size of farm was 213 acres, but farms in this area had fewer acres of cropland than those of any other area. Only 43 percent of the total farm acreage was cropland. Rotation pasture made up 1 percent, 13 percent was permanent plowable pasture, while another 43 percent was nontillable and miscellaneous.

Average size of all farms in Erie County in 1935 was 75 acres and in Crawford County in the same year 83 acres. More farms in the two counties were between 50 and 99 acres in size in 1930 than any other size. Only 1 of the 16 farms studied, however, fell within this size group, indicating that, on the whole, the farms studied were above average in size. Data on annual labor requirements of the 16 farms further substantiated this conclusion.

Dairy farming describes the prevailing type of agriculture in the area.

The ratio of tractors to farms in the area was 1 to 4, which, when compared with the ratios of the other areas included in the study, indicates that the concentration of tractors in this area was lowest.

USE OF TRACTORS

Number and Kinds of Tractors Used

The 62 cooperating farmers used a total of 74 tractors in performing their farm work during the year. Fifty-two farmers used but 1 tractor; eight, 2 tractors; and two, 3 tractors.

Nine different makes of tractors were represented - John Deere, McCormick-Deering, Oliver, Allis Chalmers, Fordson, Wallis, Huber, Caterpillar, and Cletrac. The tractors may be further classified as to type, that is, whether standard or general-purpose. 4/ Of a total of 72 wheel tractors, 16 were standards while 56 were general-purpose. Five of the standard tractors were equipped with rubber tires while 42 of the general-purpose tractors were so equipped. Of the 74 tractors, 2 were of the track-laying type.

Extent of Tractor Operations

The number of farm operations performed by tractors today is far greater than was imagined possible a few years ago by persons interested in the general problem of the mechanization of agriculture. It may not be really economical for farmers to substitute tractor power for horse power in the performance of many of the jobs around the farm that require less power than that developed by their tractors, but the fact remains that they do make this substitution of power.

4/ A standard tractor in this study is one that is not adapted for row-crop cultivation, a general-purpose tractor one that is so adapted.

Little uniformity between farmers in the extent to which they make use of their tractors was found. The number of hours that a farmer will use a tractor during the course of a year depends upon the acreage and kinds of crops grown, the adaptability of the tractor to the different farm operations, the availability and adaptability of other power, the farmer's preference for working with mechanical power compared with horse power, his farming practices, the dependence placed upon the tractor as a source of power, that is, whether the tractor is kept for general use or only to enable the "power-peaks" of the farm to be handled adequately, the type of season, and the quantity of work performed off the farm.

The average annual hours that the 16 standard tractors were used during 1938 are shown in table 2. These data are shown by size of tractor and by area.

It was not possible to determine the actual cause for the variation in the annual use of the standard tractors, but some refinement of the data was obtained by excluding those tractors that were used on multiple-tractor farms, that is, farms using more than one tractor. The exclusion of those tractors left a group of 13 standard tractors. Five of them had a rated drawbar horsepower of between 5.16 and 12.02. They were used an average of 215 hours during 1938, the range in annual hours of use being 74 to 359. The tractor that was used only 74 hours was on a farm where horses supplied most of the power; only during periods when the horses could not get work done in a limited time was the tractor used. If this tractor were excluded, the range in annual hours of use of the remaining 4 tractors would be 149 to 359.

Six of the 13 standard tractors had a rated drawbar horsepower of between 12.03 and 18.90. They averaged 328 hours of use during the year; the range in annual hours of use being 123 to 737. The tractor that was used 737 hours supplied power for operating a feed grinder for more than 100 hours. Excluding this tractor the range in annual hours of use was 123 to 297.

Two of the standard tractors used on single-tractor farms were of a rated drawbar horsepower of between 18.91 and 25.78. One was used 529 hours during the year while the other was operated 1,035 hours. The latter tractor was used very little on the home farm, most of its work being off the farm for road maintenance, threshing, and silo filling.

The operations performed by the standard tractors consisted mainly of heavy drawbar jobs like plowing, disking, and harrowing, although one or more of the tractors generally was used for some light-draft job. When compared with general-purpose tractors the standard tractors performed in some degree the same jobs, except those of operating a cultivator and a corn picker.

The average annual hours of use for the 56 general-purpose tractors are shown by size of tractor and area in table 3.

Included in the group of general-purpose tractors were those of both single and multiple-tractor farms. The elimination of those on multiple-tractor farms left a group of 38 tractors. Nine of these were of a rated drawbar horsepower of between 5.16 and 12.02. The average annual hours of use for the nine was 509, the range being 286 to 703. The tractor that was used for 703 hours was used 300 hours for custom work.

Table 2. - Average number of hours that 16 standard tractors were used in four Pennsylvania areas, 1938

Item	Rated drawbar horsepower 1/											
	5.16 to 12.02				12.03 to 18.90				18.91 to 25.78			
	Southeastern	Central	Southwestern	Northwestern	Southeastern	Central	Southwestern	Northwestern	Southeastern	Central	Southwestern	Northwestern
Number of tractors	1	1	0	4	1	3	3	1	0	1	0	1
Total hours of drawbar work	57	257	-	150	267	200	625	228	-	457	-	227
Total hours of belt work	0.0	38	-	45	58	17	76	52	-	72	-	808
Total hours of tractor work	57	295	-	195	325	217	701	280	-	529	-	1,035
Percent of total hours spent off home farm	0.0	0.0	-	6.4	0.0	0.0	0.0	0.0	-	0.0	-	87.0

1/ Ratings were taken from the Nebraska Tractor Tests. Where no tests had been made of tractors equipped with rubber tires, those tractors were classified in those classes that seemed most reasonable after all available facts were considered.

Table 3. - Average number of hours that 56 general-purpose tractors were used in four Pennsylvania areas, 1938

Item	Rated drawbar horsepower 1/											
	5.16 to 12.02				12.03 to 18.90				18.91 to 25.78			
	Southeastern	Central	Southwestern	Northwestern	Southeastern	Central	Southwestern	Northwestern	Southeastern	Central	Southwestern	Northwestern
Number of tractors	3	2	3	4	11	12	12	4	2	0	2	1
Total hours of drawbar work	194	269	478	443	465	477	317	393	141	-	319	352
Total hours of belt work	49	114	39	123	62	132	84	44	0.0	-	50	205
Total hours of tractor work	243	383	517	566	527	609	401	437	141	-	369	557
Percent of total hours spent off home farm	4.1	0.0	9.0	35.4	6.9	19.2	13.5	15.4	0.0	-	0.0	0.0

1/ See footnote 1, table 2.

There were 27 general-purpose tractors of a rated drawbar horsepower of between 12.03 and 18.90 on the single-tractor farms. They were used an average of 497 hours during the year. The range in hours of use was 66 to 1,383; the modal class - 11 tractors - fell between 450 and 599.9 hours. The tractor that was used only 66 hours during the year was on a farm where horses were used for most field work; grinding feed was the major job performed by it. The one that operated 1,383 hours during the year performed nearly one-half its work off the home farm.

Two general-purpose tractors of a rated drawbar horsepower of between 18.91 and 25.78 were used on single-tractor farms. One was used 414 hours during the year while the other was operated 557 hours.

The general-purpose tractors, like the standard tractors, were used more for heavy drawbar work than for light work, although they were used more frequently for light jobs than were the standard tractors. Except in the case of the tractors with a rated drawbar horsepower of between 18.91 and 25.78, the general-purpose tractors averaged more hours of use during the year than did standard tractors of similar drawbar horsepower.

The two track-laying tractors included in the study were used only a small number of hours during the year. One, having a rated drawbar horsepower of 18.86, was operated 208 hours on a multiple-tractor farm. The other, with a rated drawbar horsepower of 16.58, was operated on a single-tractor farm for 188 hours.

Rates of Performing Field Operations with Tractors

The rate at which field work is performed by tractors depends upon a number of factors, one of which is the amount of power available for doing the job. It was possible in this study to examine the rates of performing field operations with reference to this one factor, but only for particular implements and for general-purpose tractors. Table 4 presents the rates of performing certain field operations with general-purpose tractors of two sizes.

In connection with the analysis of rates of performance, it was noted that some farmers used implements that did not make the most economical use of the power developed. For instance, a tractor with sufficient drawbar power to pull a three-bottom, 12-or 14-inch plow is not operated most economically if it is used to pull only a two-bottom, 12-inch plow. It is recognized that as tractors become worn they develop less drawbar horsepower than when new, and that frequently an implement is used with a tractor even though the most economical use is not made of the power of the tractor. To do this often represents the best alternative open to the farmer. It is rarely true, however, that some economy in farm-power costs cannot be effected by a thorough study of better ways and means to utilize the power which is developed by the tractor.

Table 4. - Rates of performing field operations with general-purpose tractors 1/

Operation	Size of implement	General-purpose tractors of rated drawbar horsepower of -	
		5.16 - 12.02	12.03 - 18.90
		Acres per 10-hour day	Acres per 10-hour day
Plowing	1 - 16 inch	4.5	--
	1 - 18 inch	5.0	--
	2 - 12 inch	5.5	5.5
	2 - 14 inch	-	7.0
Disking (tandem)	7-foot	20.0	22.0
Harrowing	10-foot	29.0	35.0
Planting	2-row	15.0	16.0
Cultivating	2-row	17.0	19.0
Mowing	7-foot	24.0	25.0
Binding	7-foot	16.0	17.0
Combining	5-foot	-	6.5

1/ These rates were those which appeared to be most reasonable after the available data were considered. From the available observations there was no reason to believe that the rates should be different for rubber-tired tractors as compared with tractors with steel wheels.

Cost of Operating Tractors

The total cost of operating a tractor may be divided into that part which does not vary proportionately with the extent to which the tractor is used - the fixed costs - and that part which does vary somewhat proportionately with the extent of use - the variable costs. Interest on the capital invested in the tractor and depreciation to a large extent are examples of fixed costs, while the cost of fuel and oil used in the tractor are two of the variable cost items. If a tractor is bought for cash the fixed costs during a portion of its useful life may not involve large outlays of money since many of them may be temporarily deferred. They cannot be deferred indefintely, however, and, when taken for the entire life of the tractor, do constitute important cash outlays. Variable cost items cannot be deferred as readily during short periods as the fixed cost items.

It undoubtedly seems to many farmers who possess complete equity in their tractors that the cost of using them in a given year is little more than the cash expenditures involved. Actually, however, so long as the tractors must be replaced when they are worn out, and so long as alternative uses for the farmers' capital and labor exist, the cost of operating them is more than merely the cash outlays incurred.

It was not possible to prepare a good comparison of the costs of operating the tractors included in this study owing to the inadequate samples that were obtained when the tractors were sorted on the bases of type, size, and kind of wheels. Some observations, however, seem pertinent.

When the cost of operating the tractors was computed as adequately as possible, a wide variation in hourly costs was observed for tractors of the same type, the same rated drawbar horsepower, and the same wheel type. An extreme example of such variation was obtained when two general-purpose tractors of a rated drawbar horsepower of between 12.03 and 18.90 were compared.

One of the tractors was the one mentioned earlier as having been operated only 66 hours. The total variable cost for operating it was $6.85 or just slightly more than 10 cents an hour. The estimated charge for interest and depreciation amounted to $127.76 for the season, or $1.94 an hour. The sum of these costs was $2.04 an hour. This was the highest cost per hour for any of the tractors of this type and size. In contrast, a tractor of the same type and size, but operated 705 hours during the year, had a total variable cost of $67.02 or approximately 9½ cents an hour. Interest and depreciation charges amounted to $59.76, or about 8½ cents an hour, making the total cost an hour for the cost items considered 18 cents. Thus, the difference in hourly costs for operating the two tractors amounted to $1.86.

It is observed that the variable costs, when considered on an hourly basis, were little different for the two tractors. In fact, considerable uniformity in the hourly variable costs of all tractors of the same type and size was found. Fixed costs account for the great difference in the hourly cost of operating the two tractors - 8½ cents as compared with $1.94 - and are of most importance in explaining variations in the total hourly costs of all tractors of the same type and size. Errors in the judgment of farmers relative to the probable life of their tractors caused a small part of the variation in hourly fixed costs of tractors of the same size and type, but the one important factor explaining the variation was the number of hours that a tractor was used during the year. A tractor that is used relatively few hours a year, such as the one that was operated only 66 hours, has fixed costs that are distributed over few hours as contrasted to tractors that are used quite extensively.

Pointing out that hourly costs may be lowered by operating tractors a a large number of hours during the year is not to suggest that farmers use their tractors for any type of miscellaneous work just to increase the hours of use. The problem is more fundamental than this and has its roots in the reasoning whereby the decision was reached to purchase a tractor in the first instance. Even then, it cannot be said that tractors be purchased only when it can be shown that they are more economical than other types of power. As economic motives have their place, however, it is well to remind farmers that economies may result from a thorough study of the relative advantages of using different types of power in performing their farming operations.

Annual Hours of Use and Length of Life of Tractors

The length of life of a machine is determined by the wear that occurs irrespective of how much the machine is used, by the rate of obsolescence, and by the wear and tear that results from the operation of the machine. The life of present farm tractors is determined more by the third factor than by the other two, consequently, it would be expected that the estimated useful life of tractors, in terms of years, would be in inverse relation to the extent to which the tractors are used during the course of a year. In other words, a tractor

capable of operating a given number of hours during its period of usefulness would last a greater number of years if used but a few hours a year than if used a large number of hours a year.

Data for 39 general-purpose tractors of a rated drawbar horsepower of 12.03 to 18.90 were examined to observe the relationship between the hours that the tractors were used in 1938 and the estimated useful life of the tractors in years.

The 39 tractors were classified according to hours used in 1938, and then the estimated life in years of the tractors in each group was computed from reports given by the farmers. A summary of the results is shown in table 5.

Table 5. - Classification of tractors by hours used and average life

Number of tractors	Hours that tractors were used in 1938	Average life of tractors in years
Number	Hours	Years
3	0.0 - 149.9	15.0
3	150.0 - 299.9	11.3
8	300.0 - 449.9	12.9
13	450.0 - 599.9	11.2
7	600.0 - 749.9	12.3
3	750.0 - 899.9	11.3
1	900.0 - 1049.9	12
0	1050.0 - 1199.9	-
0	1200.0 - 1349.9	-
1	1350.0 - 1499.0	10

No consistent tendency was observed for tractors used a relatively large number of hours in 1938 to have a shorter estimated life in years than tractors used fewer hours. This is partly explained by the fact that the hours the tractors were used in 1938 were not indicative of the extent to which they are used normally during a 12-month period. There was evidence, too, that farmers tended to report the life of their tractors as 10 years regardless of how much they were used during a year. Of the 39 tractors, 18 were estimated to have a life of 10 years, although the range in the 1938 hours of use of the 18 was 289 to 1,383. This situation might prevail to some degree because of differences in the mechanical ability of the farmers. Some farmers, because of their ability to make repairs and attend to minor details, would be able to obtain more hours of use from them in a 10-year period than would other farmers not so adept. These differences, however, do not appear to be sufficient to account for all of the concentration around this level of estimated life.

THE USE OF HORSES 5/

Extent of Horse Operations

A few years ago, a suggestion that a farm could be so completely mechanized as to make unnecessary the use of horses would have been considered fanciful. Today, horseless farms are realities.

Of the 10 farmers who used the power of more than one tractor during the year, 6 had no workstock at all and did not hire horse work done. Of the 52 farmers who used only one tractor, 10 did the year's farming operations without the use of horses. Two of the 10 farmers had workstock that they did not use. The extent to which workstock was used on the single-tractor farms during the year is shown by tables 6 and 7.

Those farms which used horses for performing farm operations, when considered collectively, used them for many purposes, but the operations most frequently performed by them were drilling, planting, cultivating, and haying.

Horses Required

How many horses are required in combination with the power of a given size and type of tractor to perform properly the farm operations incident to the production of crops on a given acreage of cropland? The opinions of some farmers provide a basis for answering such a question. With a cropland acreage of between 50 and 99.9 acres and a general-purpose tractor of a rated drawbar horsepower of between 5.16 and 12.02, three farmers thought that they could get along without horses. Five farmers reported that they would need 2 horses while another thought that 3 horses would be required.

Farmers of another group were asked the number of horses which they considered necessary for producing crops on a cropland area of between 50 and 99.9 acres if the power of the horses were supplemented by a general-purpose tractor of a rated drawbar horsepower of between 12.03 and 18.90. Two of the group thought that they could perform the necessary farm operations without horses. Nine felt, however, that two horses would be necessary, while two believed three to be necessary, and one that four would not be too many.

THE USE OF FARM MOTORTRUCKS

Number and Kinds of Motortrucks Used

The improvement of roads and highways and continued progress on the part of automotive engineers in designing and producing motortrucks capable of greater performance at lower costs have made the motortruck an increasing part of the whole farm-power problem.

5/ The term "horses" as used in this section means workstock in general regardless of whether the work animals were horses or mules.

Table 6. - Average number of hours of horse work on farms using horses, having a combination of power of one standard tractor and horses in four areas of Pennsylvania, 1938

Item	Rated drawbar horsepower of standard tractor											
	5.16 to 12.02				12.03 to 18.90				18.91 to 25.78			
	Southeastern	Central	Southwestern	Northwestern	Southeastern	Central	Southwestern	Northwestern	Southeastern	Central	Southwestern	Northwestern
Number of farms having power combination	0	1	0	4	0	3	2	1	0	1	0	1
Number of farms having power combination using horses	0	1	0	4	0	3	2	1	0	1	0	1
Total hours horsework per farm using horses	-	567	-	1,114	-	962	675	1,901	-	1,400	0	680
Average number of horses per farm using horses	-	2	-	3.2	-	4	2	4	-	4	-	2
Average hours work per horse per year	-	284	-	348	-	241	338	475	-	350	-	340

Table 7. – Average number of hours of horse work on farms using horses, having a combination of power of one general-purpose tractor and horses in four areas of Pennsylvania, 1938

Item	Rated drawbar horsepower of general-purpose tractor											
	5.16 to 12.02				12.03 to 18.90				18.91 to 25.78			
	Southeastern	Central	Southwestern	Northwestern	Southeastern	Central	Southwestern	Northwestern	Southeastern	Central	Southwestern	Northwestern
Number of farms having power combination	0	2	3	4	2	12	9	4	0	0	1	1
Number of farms having power combination using horses	0	1	1	2	2	9	7	4	0	0	1	1
Total hours horsework per farm using horses	0	849	644	785	1,838	1,145	634	1,093	0	0	48	3,615
Average number of horses per farm using horses	0	2	3	2	3.5	2.7	2.4	3.2	0	0	2	6
Average hours work per horse per year	0	424	215	392	525	424	264	342	0	0	24	602

Of the 52 farmers having only one tractor, 24 used a motortruck in carrying on their farm operations, while each of the 10 farmers who used more than one tractor used motortrucks, 3 using 2 motortrucks. In all, there were 37 motortrucks on the 62 cooperating farms.

The 37 motortrucks were of five different makes, and ranged in size from the less than 1-ton panel and pick-up to the 4-ton general-duty type.

Extent of Motortruck Operations

Fairly complete information was obtained on the operations of 10 of the panel and pick-up trucks of less than 1-ton capacity. All of the distance traveled by the 10 trucks was for the home farms, the distance traveled during the year ranging from 800 miles in one instance to 10,000 miles in the case of two. Milk was a common product hauled by the 10 trucks. Feed and fertilizer were somewhat less important.

Twelve trucks having a load capacity of 1 and 2 tons were driven from a low of 2,000 miles during the year to a high of 14,000 miles. Of the 12, 2 were driven primarily for hire, while the other 10 were used solely for the business of the home farm. Grain, feed, and fertilizer appeared to be the products most commonly hauled by these trucks.

Nine trucks of a capacity of from 3 to 4 tons were driven from 1,000 to 18,000 miles during the course of the year. The one driven 18,000 miles was used a little more for hire than for the home farm, as it traveled 10,000 miles in performing custom work. The products hauled were generally similar to those hauled by the 1- and 2-ton trucks.

Cost of Operating Motortrucks

The total cost of operating a motortruck is made up of cost items that may be classified in the same manner as the cost items that go to make up the total cost of operating a tractor, that is, the cost items may be classified as fixed and variable, or as cash and non-cash.

Cost data were obtained for 31 of the 37 motortrucks used on the 62 farms - the same 31 motortrucks for which complete information was obtained relative to the extent of motortruck use.

The 10 motortrucks of a capacity of less than 1 ton were driven an average of 5,695 miles during 1938 at an average cost per mile of 4.1 cents (table 7). The range in cost per mile was 1.9 cents to 15.7 cents. The motortruck having the high per mile cost was driven only 800 miles. If this truck were excluded, the average cost per mile of operating the remaining 9 an average of 6,239 miles during the year would be 3.9 cents.

The group of twelve 1- to 2-ton motortrucks was driven an average of 5,833 miles at an average cost of 5.4 cents a mile. The range in per mile cost was 3.2 cents to 18.3 cents. Again the truck with the high cost per mile was driven fewer miles during the period (2,000 miles) than any one of the other 11 of the same group. The average cost of operating the other 11 was 5.1 cents a mile.

The nine motortrucks comprising the group of from 3- to 4-ton capacity were driven an average of 5,278 miles during the year at an average cost of 6.8 cents a mile. The range of per mile cost was 4.4 cents to 30.3 cents, with 8 of the 9 falling between 4.4 and 12.0 cents. The motortruck with the high per mile cost was driven only 1,000 miles, the lowest mileage driven by any one of the group.

It is observed in table 8 that the fixed-cost items constituted more than 50 percent of the total cost of operating farm motortrucks. It is these costs that explain the unusually high per mile cost of those motortrucks that were driven only a relatively few miles during the year, and it is because of these costs that farmers should consider carefully their needs for motortrucks before purchasing them. On farms where there is only limited need for a motortruck it may be found more economical to forego its purchase and to depend upon hiring one to perform the necessary hauling.

The cost of operating the 31 motortrucks has been analyzed entirely upon the basis of the number of miles that the trucks were driven. This does not represent a wholly adequate comparison of the cost of operating them, since no consideration was given to the load carried by the trucks - a factor that also affects costs. Lack of data on the extent to which the trucks were operated in a loaded condition prevents a comparison on the basis of ton-miles of hauling, but it is a comparison that must not be overlooked.

ADJUSTMENTS MADE BY FARMERS IN THE ORGANIZATION OF THEIR FARMS FOLLOWING THE SUBSTITUTION OF TRACTOR POWER FOR HORSE POWER

It was pointed out in the early pages of this report that the social and economic implications of recent technological developments in the field of farm power and equipment were of less significance to the State of Pennsylvania than to some other regions of the country, but still worthy of consideration. What then are some of these implications to this area?

Information was obtained from 60 of the 62 cooperating farmers regarding the first tractor that they had purchased. It was possible to classify these first tractors only upon the bases of type and number of plows which they pulled. A classification of them on these bases indicated that the 60 farmers had used as their first tractors 1 standard one-plow, 45 standard two-plow, 3 general-purpose one-plow, and 11 general-purpose two-plow.

The farmer who added the power of the one-plow standard tractor to the supply of power already on his farm subsequently reduced the number of his workstock by two head, but, as far as is known, did not otherwise alter the organization of his farm.

Of the 45 farmers who used two-plow standard tractors as their first tractors, 19 reduced the number of workstock maintained on their farms following the introduction of the tractors to the farm enterprises. Of these 19 farmers, 4 reduced by two head the number of workstock which were kept on their individual farms, but added dairy cows to the farm enterprise to utilize the feed and pasture released from use as horse feed. None of the 4 farmers altered the acreage of cropland on the farm following the introduction of the tractor. One of the 19 farmers reduced his workstock numbers by one head, did not increase

Table 8. - Cost of operating farm motortrucks on Pennsylvania farms, 1938

Item	Capacity of truck					
	Under 1 ton		1-2 ton		3-4 ton	
Number of trucks	10		12		9	
Miles driven 1938	5,695		5,833		5,278	
Cost per mile - cents	.041		.054		.068	
Cost items	Dollars	Percent	Dollars	Percent	Dollars	Percent
Fixed costs -						
Depreciation	76.90	33.1	122.50	38.6	118.78	32.7
Interest	15.81	6.8	26.18	8.2	32.84	9.1
License	19.75	8.5	32.67	10.3	42.67	11.8
Insurance	13.72	5.9	22.75	7.2	16.06	4.4
Total	126.18	54.3	204.10	64.3	210.35	58.0
Variable costs -						
Gasoline	61.52	26.5	76.72	24.2	96.32	26.5
Motor oil	5.26	2.3	4.87	1.5	7.58	2.1
Repairs	39.38	16.9	31.59	10.0	48.69	13.4
Total	106.16	45.7	113.18	35.7	152.59	42.0
Total	232.34	100.0	317.28	100.0	362.94	100.0

his numbers of livestock other than workstock, but did increase the acreage of his cropland by 20 acres. The remaining 14 farmers reduced the number of workstock kept per farm from two to four head - only 2 reduced the number by more than two head - but made no other significant changes in the organization of their farms.

The 26 other farmers who used a two-plow standard tractor as their first tractor did not decrease the number of their workstock following the addition of the tractor to the farms. Of these 26 farmers, 24 made no important change in the organizations of their farms after securing their first tractor, while two, though they did not decrease their numbers of workstock nor increase their numbers of livestock other than workstock, did increase their cropland acreages by 14 acres in one instance and 20 acres in another.

The three farmers who used as their first tractors the one-plow general-purpose reduced their numbers of workstock subsequent to obtaining the tractors. One of the three decreased his workstock by four head, increased his cropland acreage by 25 acres, and added 10 cows to the number already on the farm. Each of the other two farmers decreased his workstock by two head, one made no other change in the organization of his farm, while the other added 10 acres to his cropland acreage.

Of the 11 farmers who used two-plow general-purpose tractors as their first tractors, 4 did not decrease their numbers of workstock following the incorporation of the tractors into the organizations of their farms, although 2 of the 4 increased their numbers of livestock other than workstock and increased their acreages of cropland. One of the 2 increased his cow numbers by 8 head and his cropland acreage by 17 acres, while the other added 7 cows and 30 acres of cropland. The remaining 7 farmers reduced workstock numbers following the introduction of the tractors on their farms. Three of the 7 made no changes in their farm organizations except to reduce workstock numbers, 1 increased his acreage of cropland in addition to decreasing workstock numbers, while 3 increased their numbers of other livestock as they decreased their workstock numbers.

If one were to hazard a generalization from the above analysis it would be that from one-half to two-thirds of the farmers of Pennsylvania on farms comparable to those studied, who obtain as their first tractors those of an approximate rated drawbar horsepower of from 8 to 16, subsequently will reduce their numbers of workstock. The reduction will amount to about two head of workstock per farm. The one-third to one-half of the farmers who do not reduce their numbers of workstock will, in the main, not make other changes in the organizations of their farms, whereas a significant number of those farmers who do reduce their workstock numbers will also increase their acreages of cropland and/or increase their numbers of livestock other than workstock.

Sufficiently complete data were not obtained to enable one to draw definite conclusions concerning the effects which the use of tractors has upon the quantity of labor used on Pennsylvania farms. A tendency was noted, however, for those farmers who reduced their workstock numbers subsequent to obtaining a tractor to also decrease the quantity of labor used on the farms to a much greater degree than did those farmers who did not reduce their workstock numbers. This suggests that those farmers who reduced their workstock numbers were more alert in making adjustments in their farm organizations following the purchase of a tractor than were those farmers who did not reduce their workstock numbers.